

§11. Neutral Particle Transport in CHS Edge Region

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Improvement of plasma confinement such as H-mode is one of urgent issues in the fusion research. Edge transport barrier (ETB) discovered recently in the compact helical system (CHS) is characterized by clear drop of $H\alpha$ emissions. So it is expected that the profile of atomic/molecular hydrogen is one of key parameters to trigger and sustain this ETB. In order to understand the mechanism of ETB, measurement and control of neutral particle behavior are necessary. But, until now, we have only very limited experimental knowledge on them in helical systems, especially in CHS. So, we have used Monte Carlo simulation code DEGAS. We start simulation study with two-dimensional axial-symmetric model,¹⁾ then expand the simulation model into the three-dimension to include the toroidal behavior of neutral particles.^{2, 3)}

In Fig. 1, an example of 3D calculation geometry is shown, where the CHS plasma is in the standard magnetic configuration ($R_{ax} = 92.1$ [cm]) and has contact with the inside wall like as the material limiter. The neutral recycling becomes dominant at torus inside. Core plasma and “vacuum” region is divided into 45 zones poloidally and into 13 zones radially. Toroidally 48 cross sections are selected to construct the 3 dimensional mesh. Hydrogen molecules are produced at the recycling area on the wall. Hydrogen atoms are also produced near the recycling area by interactions between molecules and plasma particles. As the mean free path of these neutral particles is a few cm or less under plasma parameters around Last Closed Flux Surface (LCFS), radial and poloidal transport is almost prohibited. So, neutral density is localized to torus inside. As for toroidal transport, there exists a gap between LCFS and chamber wall. So neutral particle can easily move several cm in toroidal direction.

Though $H\alpha$ emission intensity is often used as the measure of recycling particle flux, this must be checked carefully, since $H\alpha$ emission has deep relationship with the profile of atomic/molecular hydrogen, which is very complicated in helical systems like CHS. According to Collisional Radiation (CR) model the population density of an excited level with principal quantum number p is given by

$$n(p) = R_0(p)n_i n_e + R_1(p)n_H n_e + R_2(p)n_{H_2} n_e \quad (1)$$

where population coefficients (R_0, R_1, R_2) can be calculated by Sawada code. They are less dependant on plasma density ($n_e = n_i$) and the weak increasing function of T_e . The first term of the right hand side of Eq.(1) is the contribution from recombining ions. In the CHS edge parameter region, R_0 is too smaller than R_1 or R_2 and this term can be negligible. Though R_2 is

smaller than R_2 , we must estimate balmer series emission not only from excited atoms (ie. the second term of Eq.(1)) but also from dissociating molecules (ie. the third term), since the molecular hydrogen density may be much larger in the recycling region than atomic density.

In Fig. 2, $H\alpha$ emission profiles from excited atoms (left side) and from dissociated molecules (right side) are shown. The cross section of these figures are selected to be those where a $H\alpha$ detector called as 2O is equipped and no recycling source exists. Plasma parameters are given from NBI-heated plasma data with ETB. In this cross section, $H\alpha$ emission from atomic hydrogens is larger by a factor of 10 than that from molecular hydrogens. Due to large penetration length of atoms, Fig. 2(a) shows broader profile.

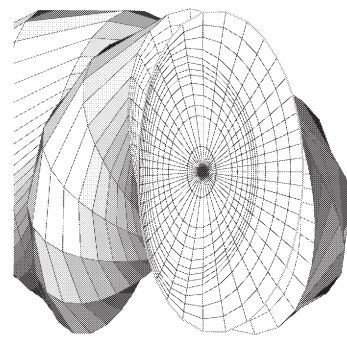


Fig. 1: Calculation geometry for the DEGAS simulation.

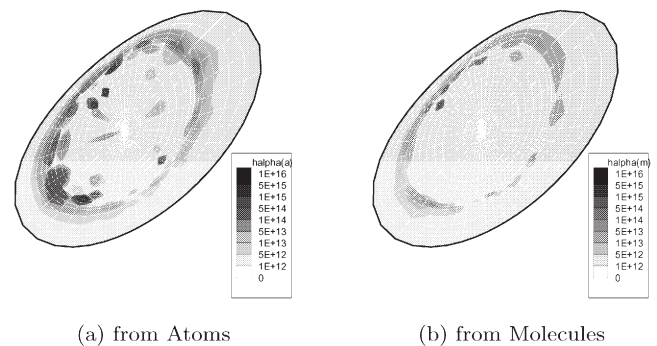


Fig. 2: $H\alpha$ emission profile at poloidal cross section where 2O detector is equipped.

References

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- 3) H.Matsuura et al.: Proc. 17th PSI17, (Hefei, 2006)P1-82.